3.5 Geophysical Investigations

The SDA has been in operation since 1952 receiving various types of waste for subsurface burial (see Section 3.1). As described in Section 3.1.2.1, the boundaries of original waste burial locations initially were marked using metal tags affixed to perimeter fencing. Later, concrete monuments replaced metal tags, but these monuments periodically were disturbed by SDA maintenance operations. Repeated disturbances eventually produced uncertainty about the true position of some pit and trench boundaries. Geophysical investigations using magnetic and electromagnetic methods have been used to delineate pit and trench boundaries, and the seismic refraction method has been used to estimate soil depth.

Magnetic and electromagnetic methods permit accurate mapping of metallic objects in the subsurface. These methods rely on the magnetic properties of iron and steel and on the contrast between the electrical current-conducting properties of metals and nonmetallic soil and waste. Magnetic and electromagnetic methods are highly selective and sensitive for detecting buried waste that contains metal objects.

Seismic methods rely on the contrast between the acoustic properties of soil and bedrock. Seismic refraction methods take advantage of the fact that sound waves propagate much faster through competent bedrock than through soil or waste. At the SDA, basalt bedrock occurs at depths of 3 to 9 m (10 to 30 ft). The shallow bedrock and overlying soil make an ideal environment for seismic refraction studies.

Table 3-10 provides a list of 10 surface geophysical studies conducted at the SDA since 1989. The geophysical surveys range in scale from single pit surveys to surveys of the full SDA. Digital data have been preserved for some of these surveys in electronic databases. In other cases, report tables and graphics provide the only record of field measurements.

Because metallic objects (including 55-gal drums) are prevalent components of many SDA waste shipments, magnetic and electromagnetic mapping has been used successfully for large-scale definition of SDA burial locations. Figures 3-5 and 3-6 are maps indicating strong geophysical anomalies used to identify features in the subsurface that have a different metallic content compared to the general surroundings. Boundaries of metal-bearing waste for most pits and trenches in the northern SDA are readily apparent. In the southern SDA, pits and trenches are not as easily defined, probably because fewer metallic objects are present (Josten and Thomas 2000).

In combination with waste disposal data in WasteOScope (see Section 3.3.3), high-resolution geophysical surveys have been used to target the location of specific waste shipments or groups of shipments. As an example, geophysical data were used at SVR-12 to locate stainless steel reactor components to be investigated as potential sources of C-14 release. Approximate locations of the target reactor components based on inventory records were plotted on high-resolution geophysical maps (see Figures 3-7 and 3-8). The number and spacing of the combined magnetic and electromagnetic geophysical anomalies roughly correspond with the number and spacing of recorded disposals. A geophysical anomaly is a portion of a geophysical survey that is different in appearance from the survey in general (Sheriff 1973). A one-to-one relationship between geophysical anomalies and specific waste shipments was apparent after evaluating inventory descriptions. The geophysical anomalies were then used to establish the actual position of stainless steel reactor components and to locate Type B lysimeter and vapor probes to monitor for C-14 release.

Other recent applications of surface geophysical data at the SDA include defining the following locations:

- Pit 9 boundary delineation

- Operable Unit 7-10 retrieval site
- Pit 9 preliminary probing campaign demonstrating probe installation
- Pit 9 40 x 40-ft probing campaign
- Pit 9 Probing Campaign 1 installing additional probes north of the 12 x 12-m (40 x 40-ft) area
- Pit 9 Probing Campaign 2 investigating high-efficiency particulate air (HEPA) filter and graphite target areas in Pit 9
- Pit 10 southwest boundary
- Depleted uranium focus area in Pit 10
- Americium and neptunium focus area in Pit 10 (see Section 3.7.7)
- Organic sludge focus area in Pit 4 (see Section 3.7.6)
- Activated metal focus area at SVR-12 and –20 (see Section 3.7.9)
- Installing deep soil vapor monitoring and extraction wells
- Installing tracer ports on north boundary of Pit 10
- Installing a well at Pad A
- Individual soil vaults in SVR-9, -10, and -13
- Individual waste shipments in Trenches 1 through 10.

Table 3-10. Summary of Subsurface Disposal Area surface geophysical surveys.

Performer	Date	Methods	Survev Area	Digital Data
UNC Geotech[a]	1989	Magnetic, electromagnetic, and seismic	Pit 9 and the Acid Pit	No
Buried Waste Robotics[b]	1991	Electromagnetic	Pit 9	No
EBASCO Environmental"	1992–93	Magnetic and electromagnetic	Entire Subsurface Disposal Area (SDA)	Yes
EG&G Idaho[d]	1992	Magnetic"	Pit 9	Yes
S. M. Stoller Corporation	1995	Magnetic, electromagnetic, and seismic	Pit 9	No
GeoSense[g]	1998	Magnetic" and electromagnetic"	Pit 9	Yes
U.S. Geological Survey[h]	1999	Electromagnetic"	Pit 9	No
Harding Lawson Associates'	1999	Magnetic," electromagnetic," and seismic	Pits 4, **6,** and 10	Yes
Sage Earth Science'	1999	Magnetic" and electromagnetic"	Pits 2, 3, and 5; Soil Vault Rows (SVRs) -1, -2, -3, -4, -5, **-6,** -7, -8, -9, -10, -11, -12, and -14	Yes
Sage Earth Science[k]	2001	Magnetic" and electromagnetic"	SVR-20	Yes

a. Hasbrouck (1989)

b. Griebenow (1992)

c. Ebasco Environmental (1993)

d. Roybal, Carpenter, and Josten (1992)

e. Indicates high-resolution surveys. Stoller Corporation (1995)

g. GeoSense 1999

h. Wright, Smith, and Abraham (1999)

i. Harding Lawson Associates (1999)

j. Sage Earth Science (1999)

k. Carpenter, Glen, Sage Earth Science, Letter Report to Jason L. Casper, Idaho National Engineering and Environmental Laboratory, Seutember 4. 2001. "Subiect: SVR-20 Geouhvsical Survev." Idaho Falls. Idaho

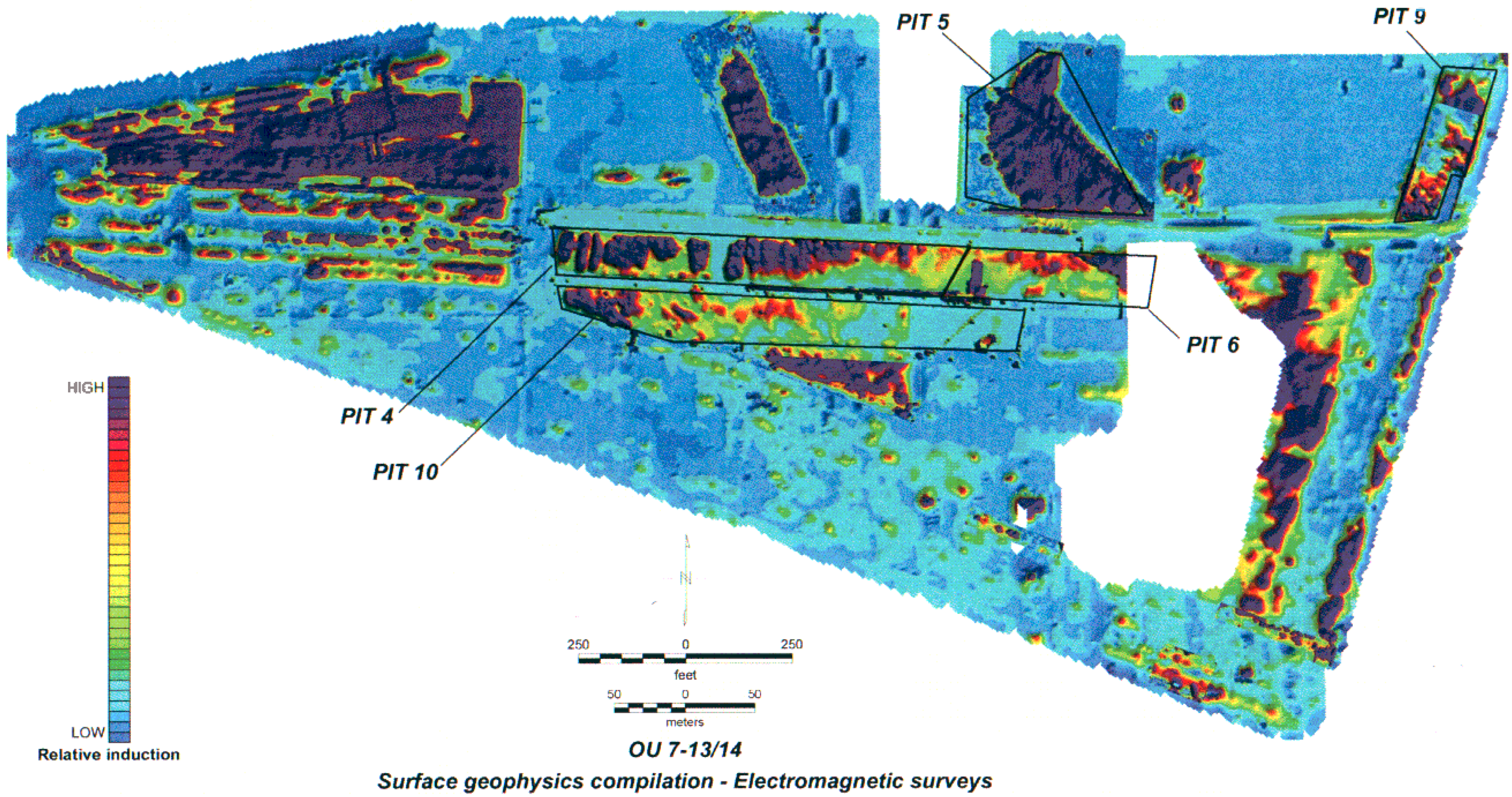

Figure 3-5. Example of a high-resolution geophysical electromagnetic survey at the Subsurface Disposal Area.

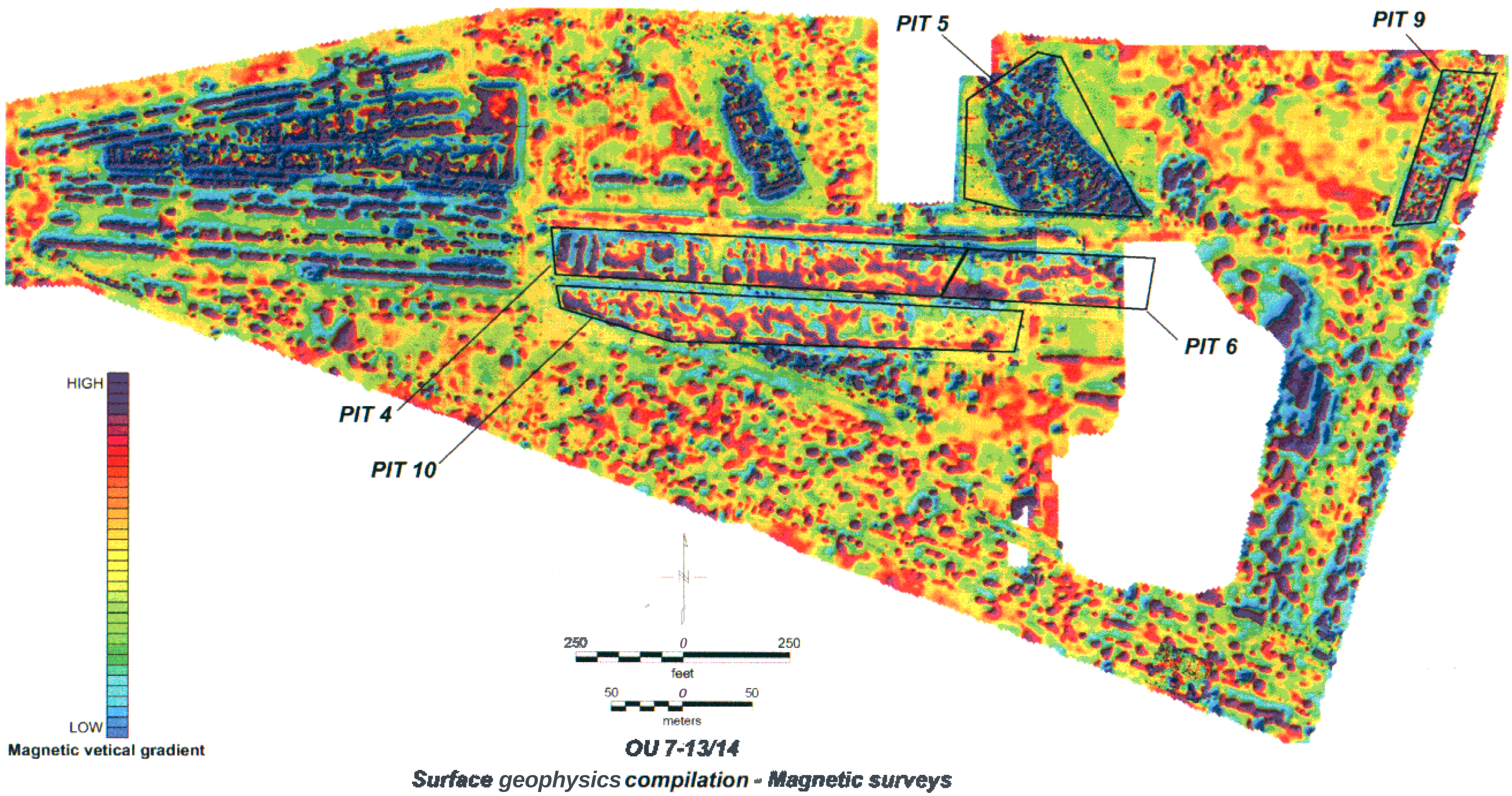

Figure 3-6. Example of a high-resolution geophysical magnetic survey at the Subsurface Disposal *Area.*

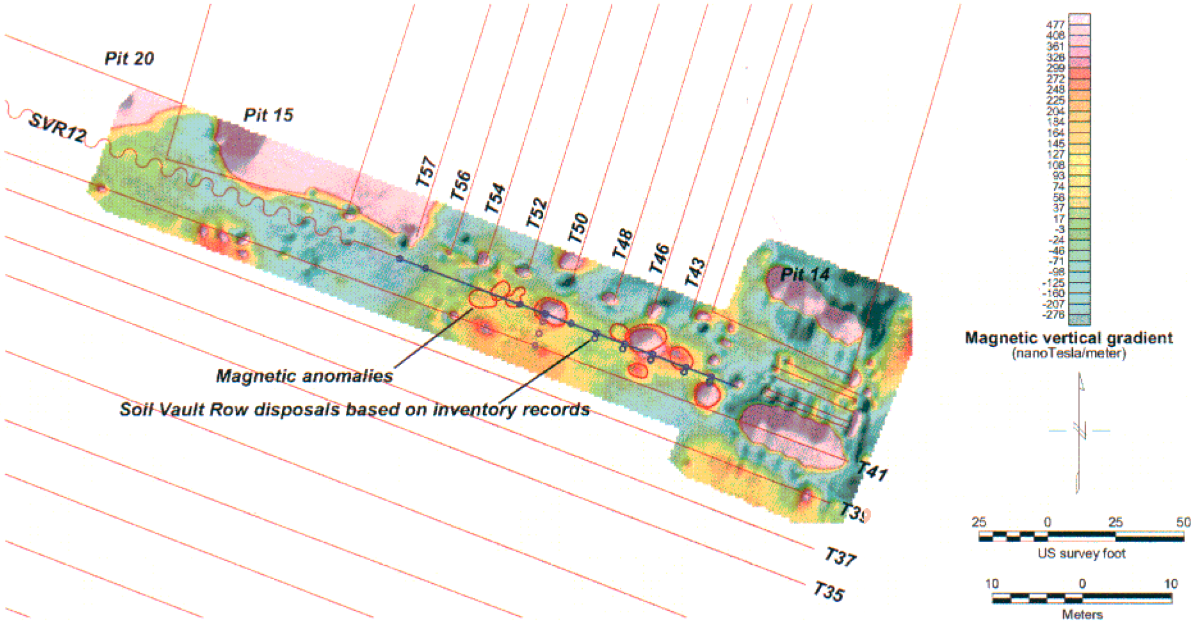

Figure 3-7. Vertical gradient magnetic data for the area surrounding Soil Vault Row 12.

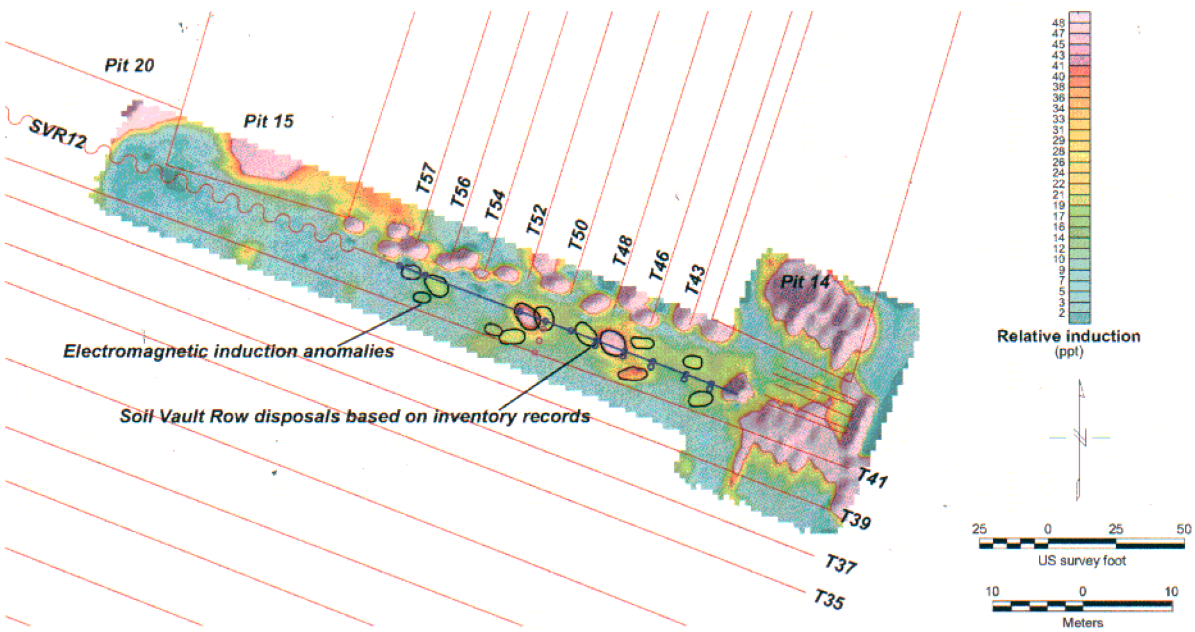

Figure 3-8. Electromagnetic induction data for the area surrounding Soil Vault Row 12.

3.5.1.1 Soil Cover Thickness Estimates Based on Surface Geophysics Data.

A high-resolution geophysical survey of Pits 4, 6, and 10 was completed in 1999. Information available from the survey includes vertical gradient magnetic data and induction electromagnetic data. A summary of soil cover thickness estimates based on the magnetic and electromagnetic data is presented in Table 3-11 (Harding Lawson Associates 1999). Estimates are based on empirical methods and apply only to metallic objects. These geophysical estimates of soil cover thickness correlate very well with historical data (see Section 3.1.6).

Table 3-11. Minimum, maximum, and average soil cover thickness for Pits 4, 6, and 10 based on surface geophysical data.

Pit	Method	Number	Minimum	Maximum (ft)[a]	Average (ft)[a]	Estimate[b] (ft)
Pit 4	Magnetics	21	2.8	14.2	6.7	6 to 9
	Electromagnetic	22	2.8	8.9	6.9	
Pit 6	Magnetics	7	4.5	12.8	7.2	4 to 7
	Electromagnetic	4	6.8	10.5	8.3	
Pit 10	Magnetics	33	3.6	17.0	7.7	6 to 8
	Electromagnetic	21	2.3	7.5	5.8	

a. Harding Lawson Associates (1999).
b. Barnes (1989).

3.6 Summary of Soil Sampling from 1959 to 1970

Studies were conducted at various locations across the INEEL between 1959 and 1970 to determine if radionuclides had migrated from buried waste into the environment. Schmalz (1972) describes these early studies, including several conducted in and around the SDA. Soil core and water samples were collected around Pits 1, 2, and 10 and Trenches 1, 9, and 48, and water samples were collected in 10 cased monitoring holes. Overall, results from the SDA suggested that contamination was detectable beneath some of the areas sampled. Schmalz (1972) hypothesized that periodic flooding of the SDA may have facilitated transport of contamination to a depth of one foot. However, radioanalytical data cited in the report do not include uncertainty values, sample-specific detection limits, laboratory quality control test results, or laboratory blank results; thus, results are not of acceptable quality. Qualitative results from Schmalz (1972) are summarized in Table 3-12.

Table 3-12. Summary of qualitative results from studies conducted at the Subsurface Disposal Area between 1959 and 1970.

Location	Media Sampled	Sample Location	Findings[a]
Western SDA	Water that collected in the bottom of cased boreholes	Ten monitoring holes throughout western part of SDA	Periodic cesium and strontium in some monitoring holes
Pit 1	Soil	Adjacent to Pit 1	Uranium and plutonium
Pit 2	Soil from two cores (0 to 12 in depth)	Bottom of the Pit 2	Possible uranium and plutonium
	Interstitial sediments taken from between the barrels	In Pit 2, between waste barrels	Possible uranium and plutonium
Pit 10	Soil from a core (0 to 8 ft depth)	4 ft from edge of Pit 10	No contamination
	Soil from a core (0 to 14 ft depth)	55 ft from edge of Pit 10	No contamination
	Soil from six cores (0 to 8 in depth)	Bottom and side of Pit 10	Uranium, plutonium, and americium
Trench 1	Soil	Adjacent to Trench 1	Possible uranium and fission activation products
Trench 9	Soil	Adjacent to Trench 9	No contamination
Trench 48	Soil from a core (0-20 ft depth)	4 ft from edge of Trench 48	Possible Ce-144, Cs-137, Zr, Nb-95
	Soil from a core (0 to 20 ft depth)	45 ft from edge of Trench 48	No contamination

a. Analytical data were not qualifiable and, therefore, concentrations are not presented.

3.7 Probing in the Subsurface Disposal Area

From December 1999 through November 2001, 337 probes were installed in the SDA to collect monitoring data directly from the waste zone. Unlike any monitoring equipment previously deployed in the SDA, most probes penetrate into buried waste to provide direct or immediately proximal monitoring capabilities. A sonic drill was used to install two kinds of probes, called Type A and Type B probes. Type A probes are hollow, bottom-sealed tubes that allow safe access into the waste zone with nuclear logging instruments. Type B probes are units equipped with various instruments or access ports to provide additional monitoring capabilities in and immediately beneath the waste. Instruments in the Type B probes include tensiometers, suction lysimeters, vapor ports, and soil moisture detectors. A special set of transparent polycarbonate tubes for visual examination of buried waste also is classified as Type B probes.

The following discussions provide information about probing in the SDA. Some information is not yet available in published reports and is provided here in detail, while other topics are summarized. Documents cited in the summaries are listed in Section 3.10. Topics below include descriptions of probing strategy; Type A and Type B probes; probing activities in Pit 9 and five focus areas in Pits 4, 5, and 10 and SVR-12 and -20; soil moisture monitoring; cover and waste zone thicknesses; and continued data collection from the SDA probes.

3.7.1 Probing Background

The probing strategy implemented in Pits 4, 5, and 10 in the SDA is described in the OU 7-13/14 Probehole Plan (INEEL 2000c), which outlined the scope and objectives for the OU 7-13/14 probing. A companion field sampling plan (Salomon 2001) provided specific sampling and monitoring requirements for data collection from Type B probes. The probing in Pit 9 was conducted in accordance with requirements of the Pit 9 Interim Action RD/RA Work Plan (LMITCO 1997). Objectives of the probing, strategy used to site probes to meet objectives, and selection of probing locations and configurations are presented below.

3.7.1.1 Probing Objectives. Data gathered from the probing are being used to support assessment of the following parameters:

- Locations of waste types, distributions of radionuclides in buried waste near the probeholes, and thicknesses of soil and waste layers
- Radiological fingerprints for identifying different waste streams
- Infiltration rates through the cover, buried waste, and underburden soil at the SDA
- Release rate and solubility of uranium
- Release rate of C-14
- Mass of the VOC source remaining in buried waste

3.7.1.2 Probing Strategy**·** The overall project strategy was to extract existing information from WasteOScope (INEEL 2001d) to identify candidate locations for waste types of interest (see Section 3.3.3). This information, summarized in the OU 7-13/14 Probehole Plan (INEEL 2000c), was used to select focus areas. Type A probes were installed in some of these focus areas during the first phase of the SDA probing project. Results from nuclear logging of Type A probes then were used to site most of the clusters of Type B probes in the second phase.

Five probing focus areas were defined for Pits 4, 5, and 10 and two soil vault rows to investigate specific waste types. To increase the likelihood of encountering a target waste stream, Type A probes typically were installed in lines, called transects, across an area of interest. Type A probes subsequently were logged, and the results were used to select optimal sites for clusters of probes. Probe clusters are collocated Type A and Type B probes deployed to study contaminant and moisture conditions in specific focus areas. The primary purpose for installing probes in clusters was to acquire information about the spatial relationships of the source mass, the net infiltration, and the leachate concentrations as a function of time.

3.7.7.3 *General Probe Locations and Configurations.* The following quantities and types of probes were installed in the SDA:

- 135 Type A probes (excludes 10 probes not logged because of shallow completions less than 1.9 m [6.3 ft] and includes five replacements for the shallow probes)
- 66 tensiometers
- 78 soil moisture probe instruments (51 physical probes, some being multi-instrumented)
- 30 vapor ports
- 18 lysimeters
- 10 visual probes.

The suite of probes used in this investigation is illustrated in Figure 3-9. The following sections provide more detail about the probe types and the criteria used for selecting their locations, the type of probe installed, and monitoring activities. An entire suite of Type B probes is represented in Figure 3-10; however, most probe configurations, or clusters, did not include every available probe type.

Specific types of probes and various configurations of probe placement in specific areas of the SDA are discussed in the following sections:

- Section 3.7.4—the Pit 9 study area
- Section 3.7.5—the depleted uranium focus area in Pit 10
- Section 3.7.6—the organic sludge focus area in Pit 4
- Section 3.7.7—the americium and neptunium focus area in Pit 10
- Section 3.7.8—uranium and enriched uranium focus area in Pit 5
- Section 3.7.9—activatedmetal investigations at SVR-12 and -20

Section 3.7.10—waste zone moisture monitoring array.

Figure 3-9. Probe suite used in the Subsurface Disposal Area probing project.

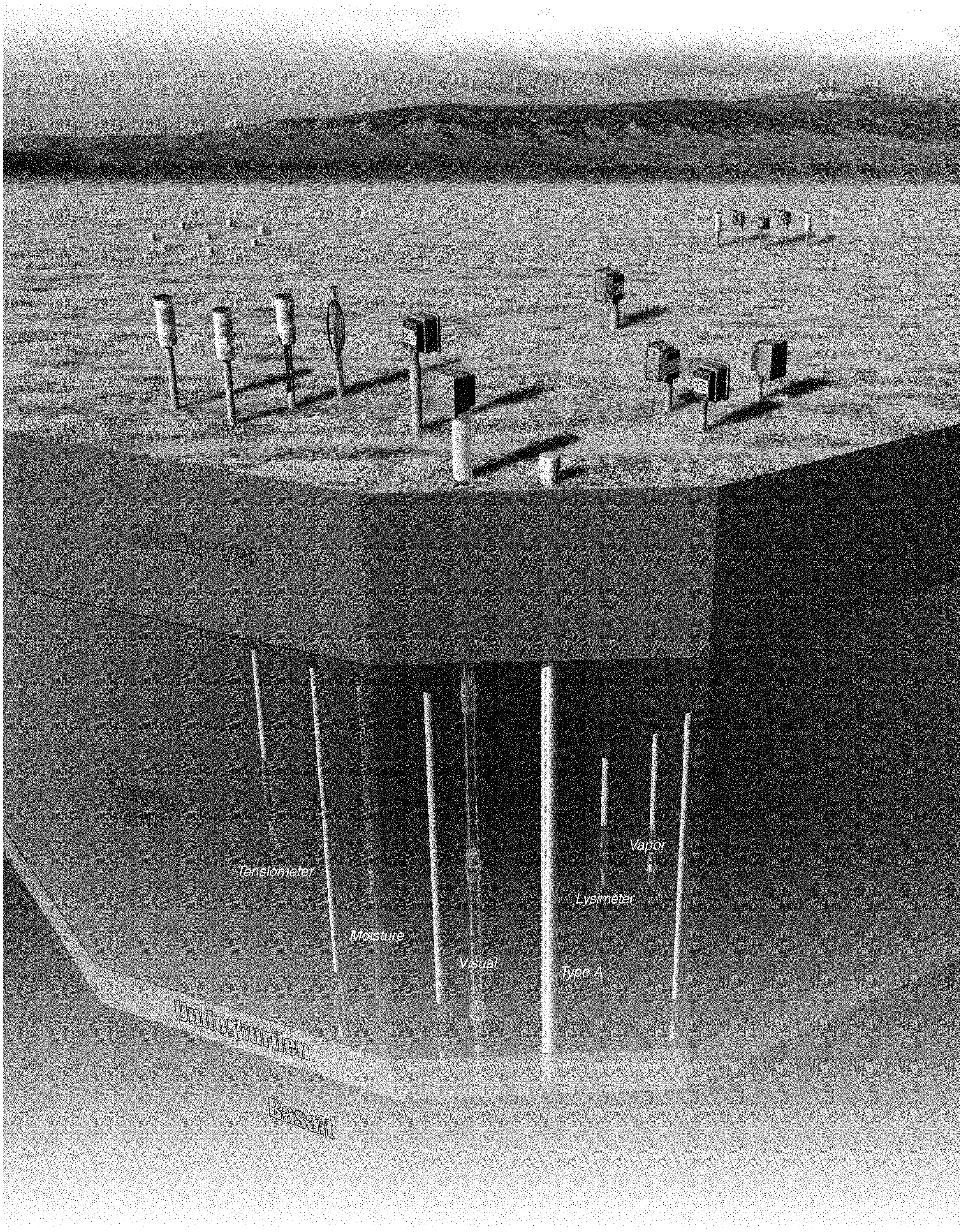

Figure 3-10. View of a typical probe suite deployed in the Subsurface Disposal Area.

3.7.2 Type A Probes and Logging Instruments

Type A probes are sealed, steel casing with a 14-cm (5.5-in.) outside diameter installed directly into the buried waste in the pits. A total of 135 Type A probes were installed in the SDA. The soil and waste adjacent to the Type A probes were characterized with nuclear logging instruments. The first set of Type A probes were placed in lines, called transects, and spaced approximately 1.8 to 2.1 m (6 to 7 ft) apart. Many Type A probes were successfully driven to the underlying basalt while some Type A probes met refusal at an interim depth in the buried waste. Subsequent probe installations included placing Type A probes between some of the original transects to form a grid, and installing close-spaced Type A probes in clusters around original Type A probes to evaluate source characteristics.

Type A probes were monitored with the following five commercially available logging instruments:

- Passive spectral gamma detector for identifying gamma-emitting radionuclides
- Neutron activation instrument to detect prompt gamma rays from neutron activation of Cl-35, an indicator for halogenated hydrocarbons (e.g., chlorine containing volatile organic compounds like carbon tetrachloride)
- Neutron-neutron detector to evaluate soil moisture
- Passive neutron detector for sensing spontaneous fission and alpha-neutron reactions (e.g., TRU constituents)
- Shielded, directional gamma detector to identify azimuthal location of gamma-emitting sources.

Detailed descriptions of these tools and results of the logging are presented in the OU 7-13/14 Probehole Plan (INEEL 2000c). Section 4 contains summaries of the results and interpretations of the nuclear logging in the waste zone for specific contaminants.

3.7.3 Type B Probes and Instrumentation

The installation and monitoring of the Type B probes is described in the Type B Probe Field Sampling Plan (FSP) (Salomon 2001). Type B probes include tensiometers, suction lysimeters, vapor ports, soil moisture detectors, and visual probes. Though geochemical probes were specified in the Probehole Plan (INEEL 2000c), the instruments did not meet development criteria and their deployment was discontinued. Instead, lysimeters and vapor ports will be used to collect data for evaluating oxidation-reduction conditions. The remainder of this section provides a brief description of various Type B probe instruments and types of data generated by the Type B probes.

3.7.3.1 **Tensiometers.** Tensiometers are used to measure either the matric potential of a porous medium under unsaturated conditions or the pressure head if saturated conditions form. Tensiometers were placed in location to provide data on the variability of moisture in the waste zone, quantify the amount and timing of moisture infiltration, and define the presence and extent of saturated conditions (Salomon 2001). Construction and design specifications of the tensiometers are described in Grover (2001).

A total of 66 tensiometers were installed throughout the SDA in nested groups of three. The upper group was placed near the overburden and upper waste contact, the middle group was placed in the upper third of the waste zone, and the lower group was placed at the underburden and waste contact or in contact with the underlying basalt, as conditions allowed. In most instances, the tensiometers were paired with soil moisture probes. Data generated by these instruments were collected on data loggers, typically taking measurements at 2-hour intervals.

3.7.3.2 Soil Moisture Probes. Soil moisture probes indirectly measure the moisture content of soil using the relationship between the soil dielectric constant and the moisture content. Probes also perform resistivity measurements of the electrical contrasts between different geologic media and indicate the temperature of surrounding material. Specifications of the soil moisture probes installed for this investigation are detailed in Anderson (2001a).

A total of 51 soil moisture probes were installed in the SDA, with 78 soil monitoring instruments. Some of these soil moisture probes have multiple instruments attached to them. As many as three soil moisture instruments were installed on some probes. In most instances, the soil moisture probes were paired with tensiometers. Probes often were nested in groups of three. The upper instruments were placed near the overburden and waste contact, the middle instruments were placed in the middle of the waste zone, and the lower instruments were placed at the underburden and waste contact or in contact with the underlying basalt, as conditions allowed. Soil moisture probes are being used to describe the following characteristics (Salomon 2001):

- Relative changes in moisture over time to corroborate and supplement matric potential measurements from tensiometers
- Extent of infiltration to corroborate and supplement matric potential measurements
- A lower-bound order of magnitude for net infiltration and drainage at the depth of the probe.

3.7.3.3 Lysimeters. Suction lysimeter probes collect soil moisture samples through application of a partial vacuum to a porous cup that is in contact with soil. Construction and design specifications of the suction lysimeters installed for this investigation are described in Clark (2001a). Lysimeter probes typically were installed in pairs using the following guidance:

- In or just below the targeted waste for that area
- At the waste and underburden contact or at the contact with underlying basalt.

A total of 18 lysimeter probes were installed—16 in Pits 4, 5, and 10 and two near SVR-12. The analytical suites for lysimeter samples are described in the Type B Probe FSP (Salomon 2001). Samples collected from the pits are analyzed for a broad range of radionuclides, VOCs, nonradioactive metals, and other inorganic constituents, depending on available sample volume. Lysimeter samples collected near the soil vaults are analyzed for a smaller suite of radionuclides to focus on those typically associated with activated metallic waste.

3.7.3.4 Vapor Ports. Commercially available vapor ports were combined with Type B probes and installed to collect soil gas from waste zones and the area surrounding soil vaults in the SDA. Specifications of vapor ports installed for this investigation are detailed in Clark (2001b). Vapor ports usually were bundled in threes and installed generally at the following three vertical horizons:

- Just below the overburden and waste contact
- Middle of the waste zone or in close proximity to a desired source in the waste
- Slightly above the waste and underburden contact.

A total of 30 vapor ports were installed—16 in Pits 4, 5, and 10 and 14 near SVR-12 and -20. One vapor port in Pit 4 malfunctioned and subsequently was abandoned. Samples collected from the pits are being analyzed in accordance with the Type B Probe FSP (Salomon 2001). All vapor samples from the pits are analyzed for VOCs. In addition, some vapor samples are analyzed to evaluate subsurface reduction/oxidation (redox) conditions by assessing O_2, CO_2, H_2, and methane. All samples collected from vapor ports surrounding soil vaults are analyzed for C-14. Samples collected at SVR-20 also are analyzed for tritium.

3.7.3.5 Visual Probes. Visual probes were installed to allow observation and investigation of the soil overburden and waste zone. Visual probes are transparent polycarbonate tubes reinforced with an internal steel cage. A miniature video camera is lowered through the visual probe to visually observe the waste and subsurface conditions. The videos are interpreted by personnel familiar with historical waste-generating processes such as at RFP and historical waste disposal operations at the RWMC.

Construction and design specifications of visual probes installed for this investigation are described in Clark (2001c). Visual probe video logs, used in conjunction with other probing data, are used to evaluate conditions in the waste zone. The following subsurface conditions can be observed:

- Location of the top and bottom of the overburden and underlying sediment
- Thickness of sediment beneath the waste
- Relative grain size of the geologic media (i.e., cobbles, pebbles, sand, silt, clay) next to the probe
- Stratification in the sediment beneath the waste or disturbance in the sediment
- Color of sediment beneath the waste for oxidation and reduction indication
- Amount of sediment versus waste adjacent to the tube in the waste zone
- Visual indication of moisture movement
- Evidence of how tightly the tube is sealing
- Condition of the drums
- Void spaces caused by drum placement or lack of material
- Presence of cellulose material (i.e., boxes, wood, paper)
- Waste form identification (e.g., sludge, graphite, combustibles, nitrate salts, or noncombustibles).

Though the video logs improved with each deployment of the video camera, several future improvements have been proposed for visual examination. The improved format and output expected from future digital video-logging activities would greatly expedite interpretation of the videos.

3.7.4 Pit 9 Study Area

Operable Unit 7-10 comprises Pit 9, which was an active disposal pit from November 1967 through June 1969 (see Section 3.2.9). The pit is approximately 4 ha (1 acre) in size and is roughly trapezoidal in shape with areal dimensions of 115 x 40 m (379 x 127 ft) (McClellan, del C. Figueroa, and King 1991).

A total of 49 Type A probes (excluding five probes with shallow penetrations) and three Type B visual probes were installed in Pit 9, as illustrated in Figure 3-11. The approach to probing in Pit 9 is described in the RD/RA Work Plan (LMITCO 1997) and summarized below.

- Pit 9 Preliminary Campaign — The Pit 9 preliminary campaign, conducted in June 1999, involved installing and logging three Type A probes outside the southeast Pit 9 boundary. Moisture and n-gamma logging was conducted in these probes to assess general soil conditions with particular emphasis on soil moisture (INEEL 2000c). The Pit 9 preliminary probing campaign was undertaken to help address safety concerns before probe installation in waste areas.

- Pit 9 40 x 40-ft Campaign — An area in Pit 9, measuring approximately 12 m (40 ft) on each side was selected for detailed subsurface investigation (see Figure 3-11). Known as the 40 x 40-ft study area, the location was selected based on waste inventory information and surface geophysical data assessed using WasteOScope (INEEL 2001d). Records indicated that the area contained a high percentage of drums containing plutonium from RFP. Twenty Type A probes were installed and logged using the full suite of geophysical logging tools, including several azimuthal logs. The primary objective of logging data analysis was to select a location in the 12 x 12-m (40 x 40-ft) area to perform a limited excavation and waste retrieval (Beitel et al. 2000; Josten and Okeson 2000).

- Pit 9 Campaign l—Pit 9 Campaign 1 involved installing eight additional Type A probes to the north of the 40 x 40-ft area to evaluate conditions in the northern part of the pit. This area was a candidate location for the Pit 9 waste excavation and retrieval. Five probes could penetrate no hrther than depths of 1.5 m (5 ft) or less and were replaced by new probes located several feet away. All Campaign 1 probes were logged with the full standard logging suite.

- Pit 9 Campaign 2—Pit 9 Campaign 2 consisted of two Type A probe arrays, one located in the northern part of Pit 9 and one located along the southeast pit boundary. The northern array included eight probes and was intended to explore for Pu-239-bearing HEPA filters. These probes have "P9-Fl-xx" designators in Figure 3-11. The southern array consisted of seven probes and was intended to explore for Pu-239-bearing graphite molds, and have "P9-GR-xx" designators in Figure 3-11. Both search locations were selected by the combined use of waste inventory records and surface geophysical data in WasteOScope. All Campaign 2 probes were logged with the full standard logging suite.

- **P9-20 Investigation—**Six additional Type A probes were installed in a circular pattern around the P9-20 probe. Initial passive gamma logging data from the Type A probe at the P9-20 location indicated a significant zone of Pu-239. This zone had a maximum apparent concentration nearly three times the next highest Pu-239 detection in Pit 9 and an order of magnitude greater than the next highest reading for Pu-239 detection in any other Type A probe in the SDA. The specific objective of the additional six cluster Type A probes was to obtain detailed information needed to evaluate criticality potential.

- Data from the six additional Type A probes showed a decrease of one to two orders of magnitude in Pu-239 levels than observed in P9-20. Furthermore, the data indicated that the Pu-239 source was contained entirely in the circle of probes, and that the source volume and mass are much smaller than previously speculated. The spectral data indicate that a point or small distributed, concentrated source exists. This interpretation of the probe data is consistent with historical WasteOScope records that drums containing graphite molds were disposed of in the area Graphite molds could have had plutonium fixed to their surfaces or wedged in cracks in the molds.

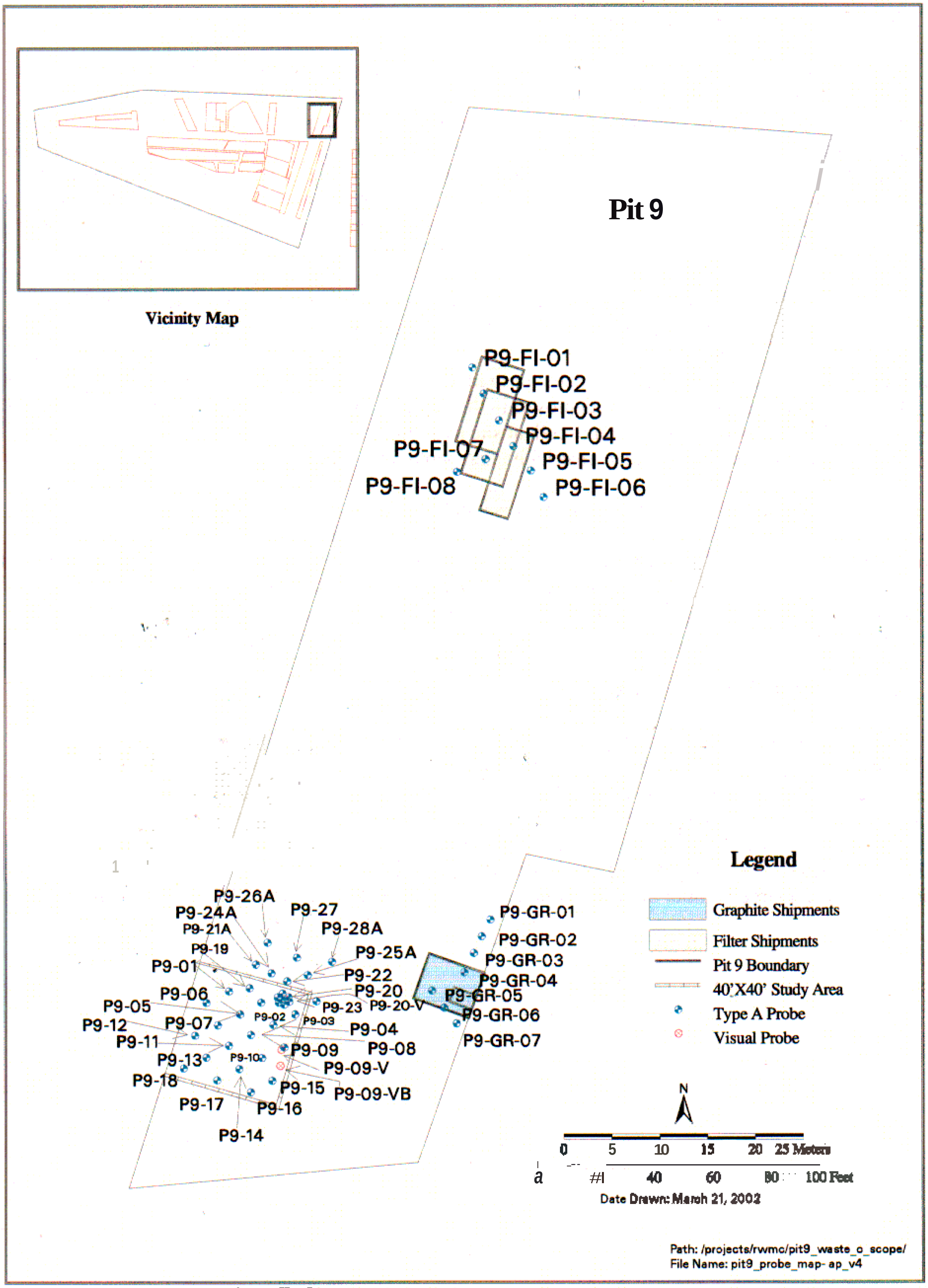

Figure 3-11. Probes installed in the Pit 9 study area.

3.7.5 Depleted Uranium Focus Area

Depleted uranium from RFP is the dominant uranium waste form in the SDA. Depleted uranium material, called roaster oxide, was exposed to a flame and roasted (i.e., oxidized), allowing for safe shipping and storage of this otherwise pyrophoric material. Information from WasteOScope (INEEL 2001d) indicated that the west end of Pit 10 contained depleted uranium. Geophysical surveys indicated that metallic objects were present in this area. Type A probes were first installed along two transects in the depleted uranium focus area and later additional Type A probes were installed between the transects (see Figure 3-12). Probes DU-01 through DU-08 compose the two original probe transects. Interpreted results from these probes are documented in the Type B Probe FSP (Salomon 2001, Appendix D).

Locations for Type B probe clusters were identified from the Type A logging data. The highest concentrations of uranium detected in the depleted uranium focus area were found at locations DU-10 and DU-14, indicating that the locations were optimal for Type B probe clusters. The Type A probes were then logged using a directional gamma detector to identify azimuthal location of gamma-emitting sources in May 2001. A third cluster also was deployed in the depleted uranium focus area because geophysical logging results indicated that it was an excellent site to monitor neptunium waste. This site, DU-08, is described under the discussion on the americium and neptunium focus area in Section 3.7.7.

In addition, a depleted uranium source was identified in the organic sludge focus area in the east end of Pit 4. The highest level of U-238 detected in any Type A probe was found at Probe 743-08. This probe also was selected as the origin of a probe cluster to characterize organic sludge and, thus serves for both depleted uranium and organic sludge characterization. The primary clusters and probes used to characterize depleted uranium waste are listed in Table 3-13, which includes the probes in Probe Cluster 743-08.

3.7.6 Organic Sludge Focus Area

Organic compounds buried in the SDA include carbon tetrachloride, methylene chloride, TCE, TCA, PCE, heavy lubricating oils, polychlorinated biphenyls, chlorofluorocarbons, alcohols, organic acids, ethylenediaminetetraacetic acid (EDTA, also known as Versenes) and nitrobenzene. The primary contributors to potential risk in the IRA (Becker et al. 1998) from organic sludge were carbon tetrachloride, methylene chloride, and PCE. Ninety-eight percent of the CCl_4 was originally contained in RFP 743-series sludge. Information from WasteOScope (INEEL 2001d) indicated that the east end of Pit 4 contained a large number of drums containing 743-series sludge. High VOC soil gas concentrations

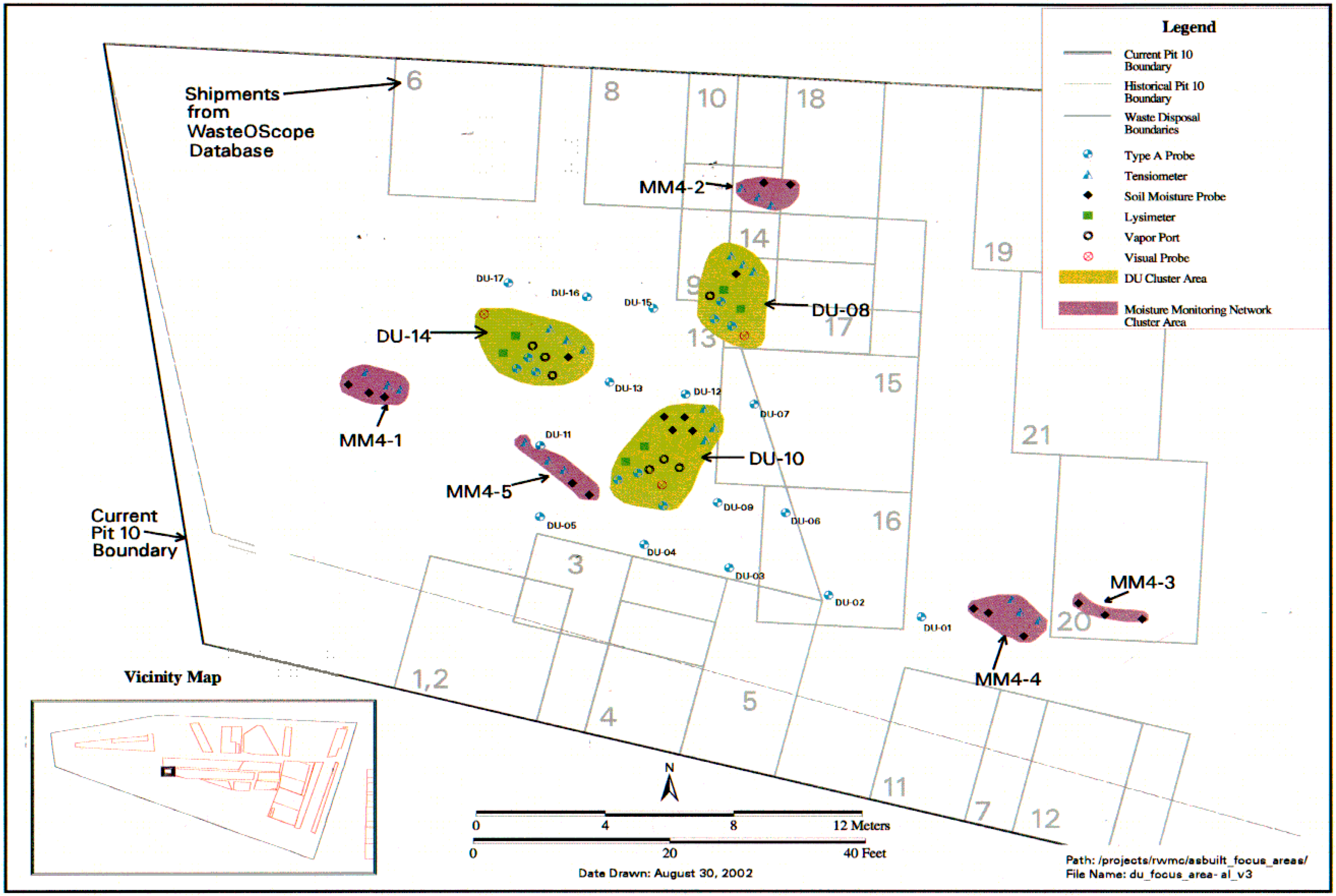

Figure 3-12. Probe clusters installed in and around the depleted uranium focus area in the west end of Pit 10.

Table 3-13. Probe completions, by cluster, in the west end of Pit 10 and the east end of Pit 4 supporting depleted uranium waste assessment.

	Probe Type											
	Type A Probe		Tensiometer		Soil Moisture Probe		Lysimeter		Vapor Port		Visual Probe	
Cluster Name	Probe Name	Probe Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Probe Depth (ft)
DU-10	DU-10	17.3	DU-10-T3	9.1	DU-10-M1	9.2	DU-10-L1	9.8	DU-10-VP1	11.5	DU-10-V	7
	DU-10-A	17.0	DU-10-T2	6.7	DU-10-M2	6.6	DU-10-L2	7.0	DU-10-VP2	10.0		
	DU-10-B	17.2	DU-10-T1	4.0	DU-10-M3	4.0			DU-10-VP3	6.2		
					DU-10-MD	6.7						
DU-14	DU-14	17.3	DU-14-T3	15.3	DU-14-M1	15.2	DU-14-L1	16.0	DU-14-VP1	16.0	DU-14-V	10.5
	DU-14-A	17.5	DU-14-T2	9.0	DU-14-M1	9.8	DU-14-L2	7.9	DU-14-VP2	11.7		
	DU-14-B	17.6	DU-14-T1	3.7	DU-14-M1	4.5			DU-14-VP3	4.9		
743-08	743-08	25.3	743-08-T3	22.4	743-08-M1	22.3	743-08-L1	23.3	743-08-VP1	20.2	743-08-V	13.6
	743-08-1	25.6	743-08-T2	13.0	743-08-M1	13.9	743-08-L2	9.0	743-08-VP2	13.4		
	743-08-2	25.0	743-08-T1	5.6	743-08-M1	6.6			743-08-VP3	4.9		
	743-08-3	26.3										
	743-08-4	24.1										
	743-08-5	25.0										
	743-08-6	25.1										

that have been detected over the east end of Pit 4 corroborated that drums containing 743-series sludge were buried there. The VOC concentration was corroborated further from results of Type A logging. Most of these probes logged with the n-gamma tool indicated elevated chlorine detections across the focus area. Chlorine is indicative of chlorine-bearing wastes such as VOCs and polyvinyl chloride plastic.

Investigation in the east end of Pit 4 was undertaken primarily to collect data to evaluate the mass of VOCs remaining in the buried waste, using a combination of shallow and waste zone vapor probes, nuclear logging of the Type A probes, flux chamber measurements, and modeling. A long transect of Type A probes first was installed in the eastern side of Pit 4 (see Figure 3-13). The area investigated contained a significant quantity of organic sludge. The probe transect was designed to originate in an area where VOC-containing waste drums were heavily concentrated, and extend to an area with minimal VOC-containing waste. The transect passed through 30 delineated waste shipments recorded for the area in Pit 4. Of these disposals, 26 originated from Rocky Flats and contained 743-series sludge, which contains high concentrations of VOCs. The 30 disposals contained approximately 2,819 drums, of which 1,077 (38%) were drums of 743-series sludge (INEEL 2000c). Using WasteOScope, shallow soil gas and geophysical data were used to aid in the placement of the transect.

Figure 3-14 is an example of a recent soil gas survey and shows that high levels of carbon tetrachloride are in the northeast comer of Pit 4, which corresponds well with the disposal records described above. The survey was conducted after placement of the original probe transect and is given here because the data set is more current than the original shallow soil gas survey data. Figure 3-15 represents an electromagnetic geophysical survey conducted over the same area. This survey indicates the presence of metallic objects, probably drums, in a wide area of the eastern section of Pit 4 and also indicates substantially less metallic material in the southern portion of the pit. Data from these types of surveys supported the plan to place probes over a transect covering a high to low concentration of VOC-bearing waste.

Multiple disposals of organic sludge were concentrated in the east end of Pit 4. Accordingly, precision was less important in choosing locations for the Type B clusters. The three primary probe cluster locations were chosen to cover a large areal extent of the transect and also to cover a range of chlorine detections generated from nuclear logging data.

Location 743-03 was chosen as the origin of a probe cluster because it had the highest chlorine signature collected from any Type A probe along the transect. According to WasteOScope, this location also contained numerous organic sludge disposals and previous soil gas surveys indicated elevated VOC concentrations. Location 743-08 was selected for much the same reason. In addition, this location contained the largest detection of U-238 daughter products and, thus, was able to provide valuable information about depleted uranium characteristics in addition to data about the organic sludge. Location 743-18 was selected because it is in the transition area between disposals that contain organic sludge and those that do not. Type A logging data indicated the presence of chlorine, but at substantially lower concentrations than identified at 743-03 and 743-08. The data interpretations used to locate the Type B probe clusters are given in the Type B Probe FSP (Salomon 2001, Appendix D). The types and completion depths of probes used to form clusters in the organic sludge focus area are listed in Table 3-14.

3.7.7 Americium and Neptunium Focus Area

The primary source of Am-241 and Np-237 in the SDA is the RFP 741-series sludge (i.e., first stage wastewater sludge). An area in the central part of Pit 10 was identified as the americium and neptunium focus area. Disposal numbers[g] 195, 196, 205, 206, and 207 in that location were of special

g. Disposal numbers are artifacts of early versions of WasteOScope and were applied in probehole planning documents, figures, and other aspects of the probing implementation. These numbers no longer appear in WasteOScope.

Probe Name	Probe Type	Probe Depth (ft)
743- 01	Type A	17.2
743- 02	Type A	20.7
743- 03	Type A	19.5
743- 04	Type A	25.5
743- 05	Type A	27.0
743- 06	Type A	26.2
743- 07	Type A	25.3
743- 08	Type A	25.3
743- 08- 1	Type A	25.6
743- 08- 2	Type A	25.0
743- 08- 3	Type A	26.3
743- 08- 4	Type A	25.1
743- 08- 5	Type A	25.0
743- 08- 6	Type A	25.1
743- 09	Type A	24.3
743- 10	Type A	25.8
743- 11	Type A	25.5
743- 12	Type A	25.0
743- 13	Type A	25.6
743- 14	Type A	23.0
743- 15	Type A	21.9
743- 16	Type A	16.2
743- 17	Type A	20.7
743- 18	Type A	21.0
743- 19	Type A	4.2
743- 20	Type A	16.3
743- 21	Type A	14.8
743- 22	Type A	21.4
743- 23	Type A	8.4
743- 24	Type A	23.5
743- 25	Type A	17.8
743- 32	Type A	12.1
743- 33	Type A	12.1
743- 34	Type A	11.9
743- 35	Type A	16.4
743- 36	Type A	25.8
743- 37	Type A	25.8
743- 38	Type A	15.5
743- 39	Type A	19.8
743- 40	Type A	18.4
743- 41	Type A	21.5
743- 42	Type A	22.2
743- 03- V	Visual Probe	13.6
743- 08- V	Visual Probe	13.6
743- 18- V	Visual Probe	12

Probe Name	Probe Type	Sensor/Port Bottom Depth from Surface (ft)
743- 03- L1	Lysimeter	12.8
743- 03- L2	Lysimeter	9.8
743- 08- L1	Lysimeter	23.3
743- 08- L2	Lysimeter	9.0
743- 18- L1	Lysimeter	12.1
743- 18- L2	Lysimeter	12.8
743- 03- M1	Soil Moisture Probe	19.1
743- 03- M1	Soil Moisture Probe	12.3
743- 03- M1	Soil Moisture Probe	3.4
743- 08- M1	Soil Moisture Probe	22.3
743- 08- M1	Soil Moisture Probe	13.9
743- 08- M1	Soil Moisture Probe	6.6
743- 18- M1	Soil Moisture Probe	19.2
743- 18- M1	Soil Moisture Probe	12.8
743- 18- M1	Soil Moisture Probe	6.5
743- 03- T1	Tensiometer	5.3
743- 03- T2	Tensiometer	11.2
743- 03- T3	Tensiometer	18.5
743- 08- T1	Tensiometer	5.6
743- 08- T2	Tensiometer	13.0
743- 08- T3	Tensiometer	22.4
743- 18- T1	Tensiometer	5.5
743- 18- T2	Tensiometer	14.9
743- 18- T3	Tensiometer	9.2
743- 03- VP1	Vapor Port	18.0
743- 03- VP2	Vapor Port	13.3
743- 03- VP3	Vapor Port	4.8
743- 08- VP1	Vapor Port	20.2
743- 08- VP2	Vapor Port	13.4
743- 08- VP3	Vapor Port	4.9
743- 18- Abandoned	Vapor Port	14.3
743- 18- VP1	Vapor Port	20.0
743- 18- VP3	Vapor Port	7.6
743- 18- VP4	Vapor Port	14.6

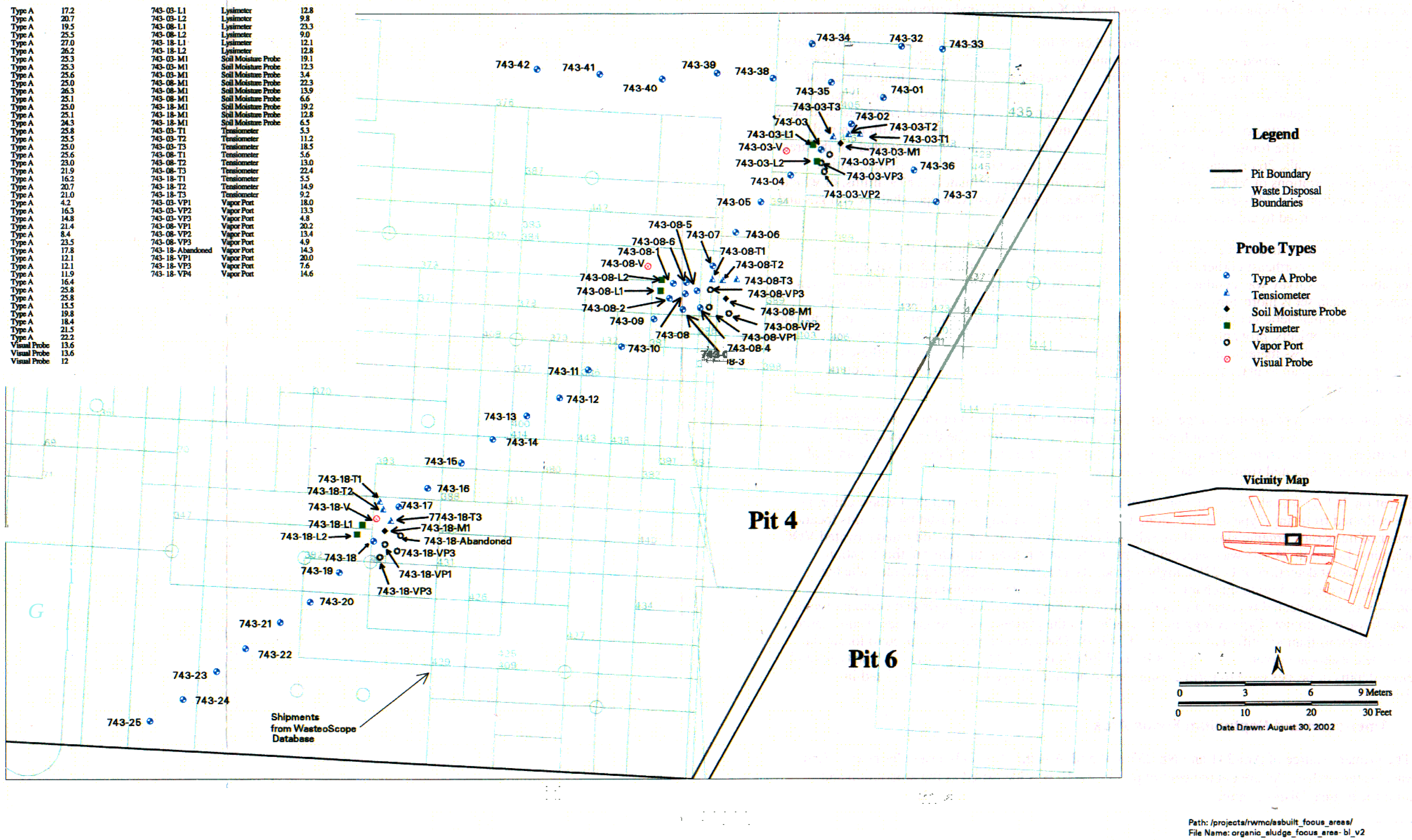

Figure 3-13. Probes installed in the organic sludge focus area in the eastern end of Pit 4.

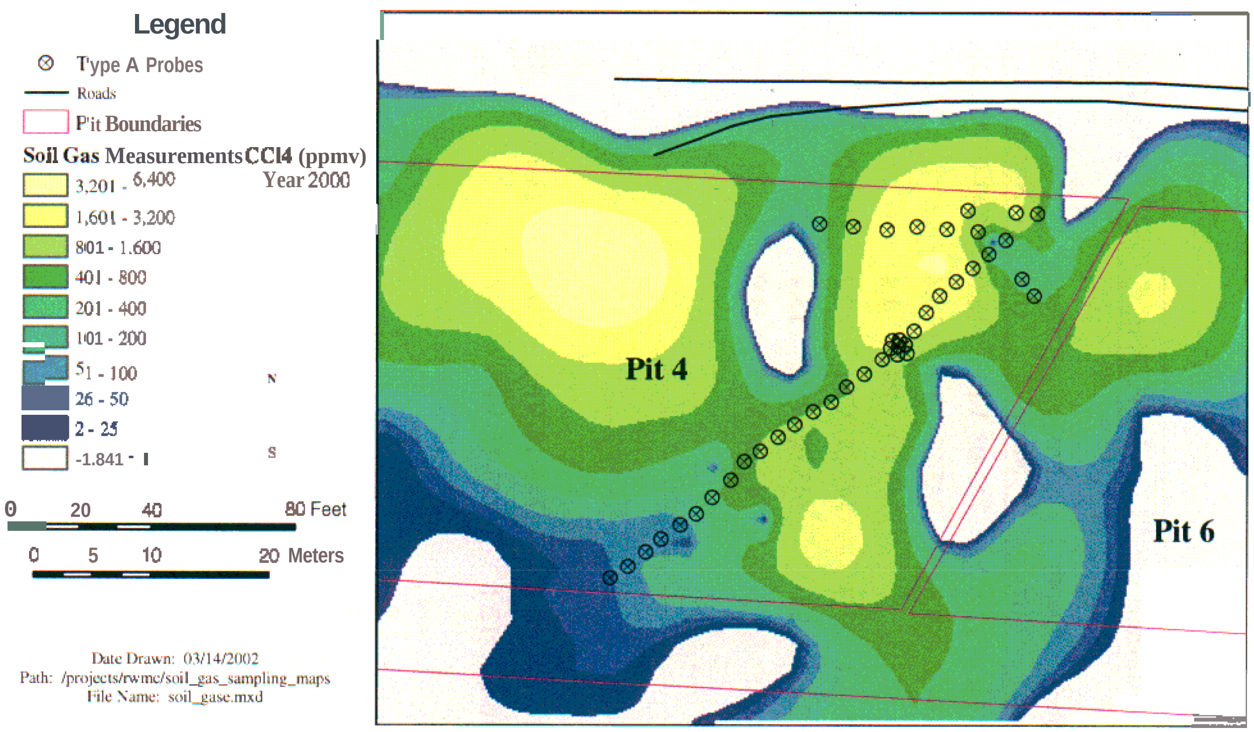

Figure 3-14. Relationship of shallow soil gas survey and Type A probe placement in the east end of Pit 4.

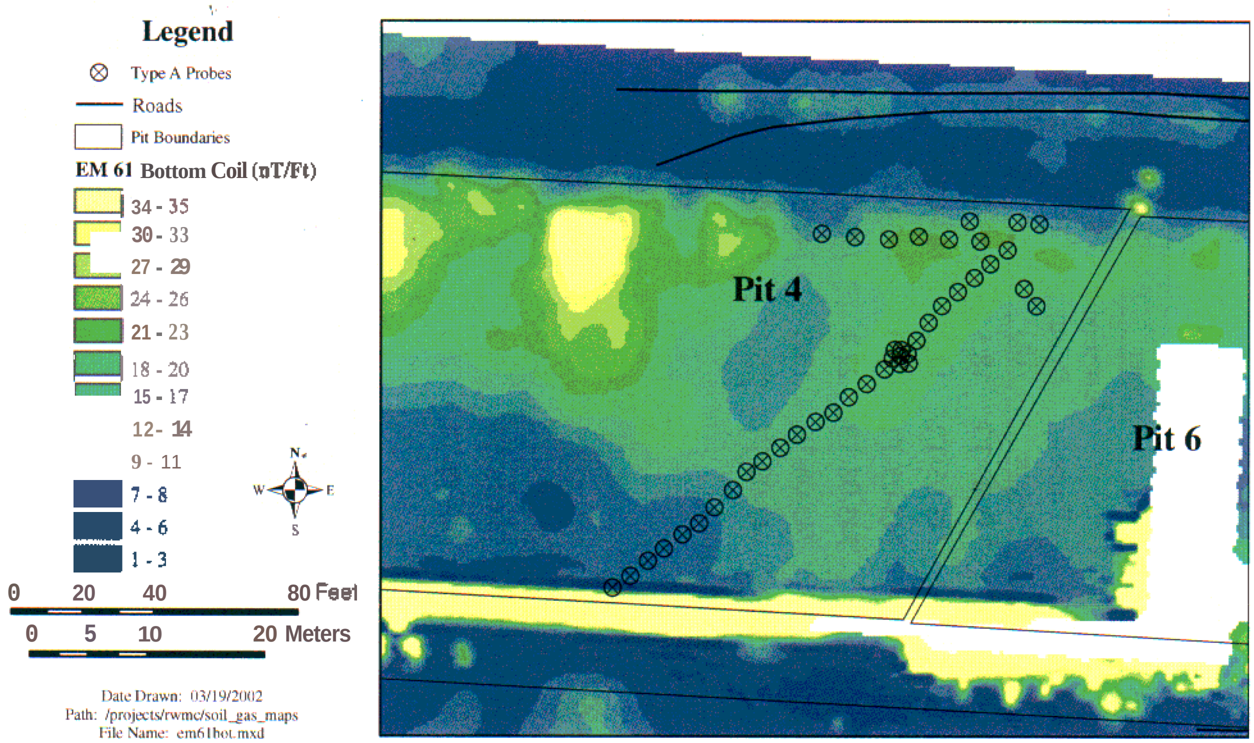

Figure 3-15. Relationship of geophysical survey and Type A probe placement in the east end of Pit 4,

Table 3-14. Probe completions, by cluster, in the organic sludge focus area in the east end of Pit 4.

	Probe Type											
	Type A Probe		Tensiometer		Soil Moisture Probe		Lysimeter		Vapor Port		Visual Probe	
Cluster Name	Probe Name	Probe Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Probe Depth (ft)
743-03	743-03	19.5	743-03-T3	18.5	743-03-M1	19.1	743-03-L1	12.8	743-03-VP1	18.0	743-03-V	13.6
			743-03-T2	11.2	743-03-M1	12.3	743-03-L2	9.8	743-03-VP2	13.3		
			743-03-T1	5.3	743-03-M1	3.4			743-03-VP3	4.8		
743-08	743-08	25.3	743-08-T3	22.4	743-08-M1	22.3	743-08-L1	23.3	743-08-VP1	20.2	743-08-V	13.6
	743-08-1	25.6	743-08-T2	13.0	743-08-M1	13.9	743-08-L2	9.0	743-08-VP2	13.4		
	743-08-2	25.0	743-08-T1	5.6	743-08-M1	6.6			743-08-VP3	4.9		
	743-08-3	26.3										
	743-08-4	25.1										
	743-08-5	25.0										
	743-08-6	25.1										
743-18	743-18	21.0	743-18-T2	14.9	743-18-M1	19.2	743-18-L2	12.8	743-18-VP1	20.0	743-18-V	12
			743-18-T3	9.2	743-18-M1	12.8	743-18-L1	12.1	743-18-VP3	7.6		
			743-18-T1	5.5	743-18-M1	6.5			743-18-VP4	14.6		

interest for two reasons: (a) the disposals contain relatively large numbers of 741-series drums, and (b) because the 741-series drums occur in high ratios relative to other types of waste drums in the same disposals. For example, Disposals 195 and 196 contained a total of 301 drums and 169 of those drums contained 741-series sludge. Similarly, Disposals 205, 206 and 207 contained 293 drums, of which 137 contained 741-series sludge. Specific contents of the shipments are listed in the OU 7-13/14 Probehole Plan (INEEL 2000c). The Probehole Plan also gives rationale and figures derived from past geophysical surveys to support placement of the probes in this focus area. Historical disposal information was used to demarcate a general area, then geophysical survey data were used to refine the probe location selection. Initial probe data were evaluated to further refine additional probe locations.

The americium and neptunium focus area was investigated to determine a fingerprint of this high-activity waste stream in the SDA environment. Both Am-241 and Np-237 were identified as COPCs in the IRA (Becker et al. 1998). Though the waste may have contained Np-237 at the time of disposal, some Np-237 is produced through decay of Am-241. The primary waste stream containing Am-241 is the 741-series sludge, which contains more than 80% of the Am-241 buried in the SDA. Disposal of this waste stream occurred from 1954 to 1970.

Locations of probes installed in the americium and neptunium focus area are shown in Figure 3-16. Location 741-08 had higher observed concentrations of Pu-239, Am-241, and Np-237 than other locations in this focus area. In addition, DU-08 in the depleted uranium focus area (see Figure 3-12) contained an excellent source for monitoring neptunium waste. The primary clusters and probes used to characterize the americium and neptunium focus area are listed in Table 3-15.

As noted in Section 3.6.5, the other Type A probe used to establish a probe cluster to study americium and neptunium waste was identified in the depleted uranium focus area. Nuclear logging data from this probe indicated that the highest concentration of neptunium-bearing waste was detected at DU-08. A cluster was installed there to monitor this type of waste. The probes installed at DU-08 are given in Figure 3-12, which shows the depleted uranium focus area in the west end of Pit 10.

3.7.8 Uranium and Enriched Uranium Focus Area in Pit 5

Three areas in Pit 5 were investigated to locate areas of enriched uranium and other uranium waste streams. One area in the north part of Pit 5 was selected based on monitoring data. The other two areas were selected using WasteOScope. The probe names and the location and completion intervals for probes installed in this investigation are provided in Table 3-16 and Figure 3-17. The individual areas probed in Pit 5 are discussed below.

Pit 5-TW1. Type B probes, including a lysimeter, were located in Pit 5 next to lysimeter TW-1, where both U-236 and enriched uranium (i.e., anthropic uranium) had been previously detected in soil moisture collected from a depth of approximately 31 m (102 ft) (Roback et al. 2000). The area surrounding TW-1 also exhibits a topographic depression on the upper basalt surface (see Figure 3-17). This geologic feature may cause local infiltration around Pit 5 and Pad A to move in the direction of TW-1. Therefore, Type B probes were located in this area. The sampling port on the Type B lysimeter Pit 5-TW1-L1 was completed at 3.7 m (12.2 ft) and is assumed to be next to the contact with the underlying basalt. To date, however, the lysimeter has not yielded soil moisture samples.

Pit 5-1. Type A probes were placed in an area shown by WasteOScope to contain two collocated disposals of U-233 waste from RFP Building 881. Building 881 focused on enriched uranium manufacturing and recovery through the mid-1960s. However, Building 881 also housed numerous special projects, some of which involved U-233. Thirty-nine of the 370 drums reported for two disposals

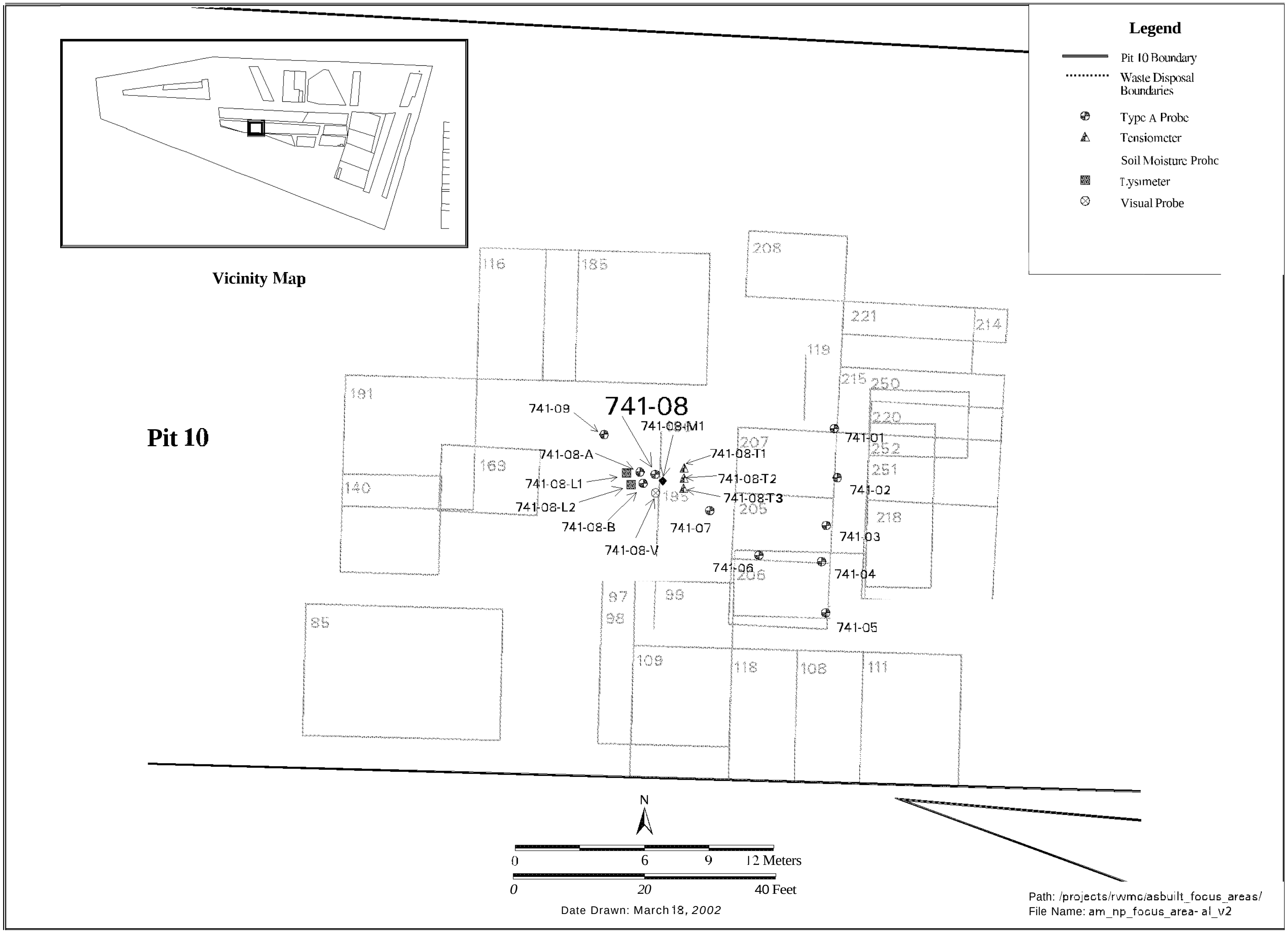

Figure 3-16. Probes installed in the americium and neptunium focus area in the central part of Pit 10.

Table 3-15. Probe completions, by cluster, supporting americium and neptunium waste assessment in Pit 10.

	Probe Type											
	Type A Probe		Tensiometer		Soil Moisture Probe		Lysimeter		Vapor Port		Visual Probe	
Cluster Name	Probe Name	Probe Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Probe Depth (ft)
DU-08	DU-08	18.7	DU-08-T3	16.4	DU-08-M1	17.9	DU-08-L1	16.1	DU-08-VP2	15.8	DU-08-V	17.6
	DU-08-A	18.1	DU-08-T2	10.2	DU-08-M1	11.5	DU-08-L2	14.1				
	DU-08-B	17.6	DU-08-T1	5.3	DU-08-M1	6.1						
741-08	741-08	22.3	741-08-T3	19.9	741-08-M1	19.9	741-08-L1	15.2			741-08-V	13.5
	741-08-A	20.8	741-08-T2	10.6	741-08-M1	11.5	741-08-L2	7.8				
	741-08-B	21.8	741-08-T1	3.6	741-08-M1	4.1						

Table 3-16. Probe completions, by cluster, supporting uranium waste assessment in Pit 5.

Cluster Name	Type A Probe: Probe Name	Type A Probe: Probe Depth (ft)	Soil Moisture Probe: Probe Name	Soil Moisture Probe: Instrument Depth (ft)	Lysimeter: Probe Name	Lysimeter: Port Depth (ft)
Pit 5-1	Pit 5-1-1	7.8				
	Pit 5-1-2	7.8				
	Pit 5-1-3	9.1				
	Pit 5-1-4	8.5				
	Pit 5-1-5	3.8				
	Pit 5-1-6	11.7				
	Pit 5-1-7	16.0				
	Pit 5-1-8	13.6				
Pit 5-4	Pit 5-4-1	16.5	Pit 5-4-M	10.2	Pit 5-4-11	10.6
	Pit 5-4-2	16.4	Pit 5-4-MB	8.2		
	Pit 5-4-3	16.3	Pit 5-4-MB	2.8		
	Pit 5-4-4	12.7				
	Pit 5-4-5	10.5				
	Pit 5-4-6	16.5				
	Pit 5-4-7	14.1				
Pit 5-TW1			Pit 5-TW1-M	10.2	Pit 5-TW1-L1	12.2
			Pit 5-TWl-MB	8.2		
			Pit 5-TW1-MB	2.9		

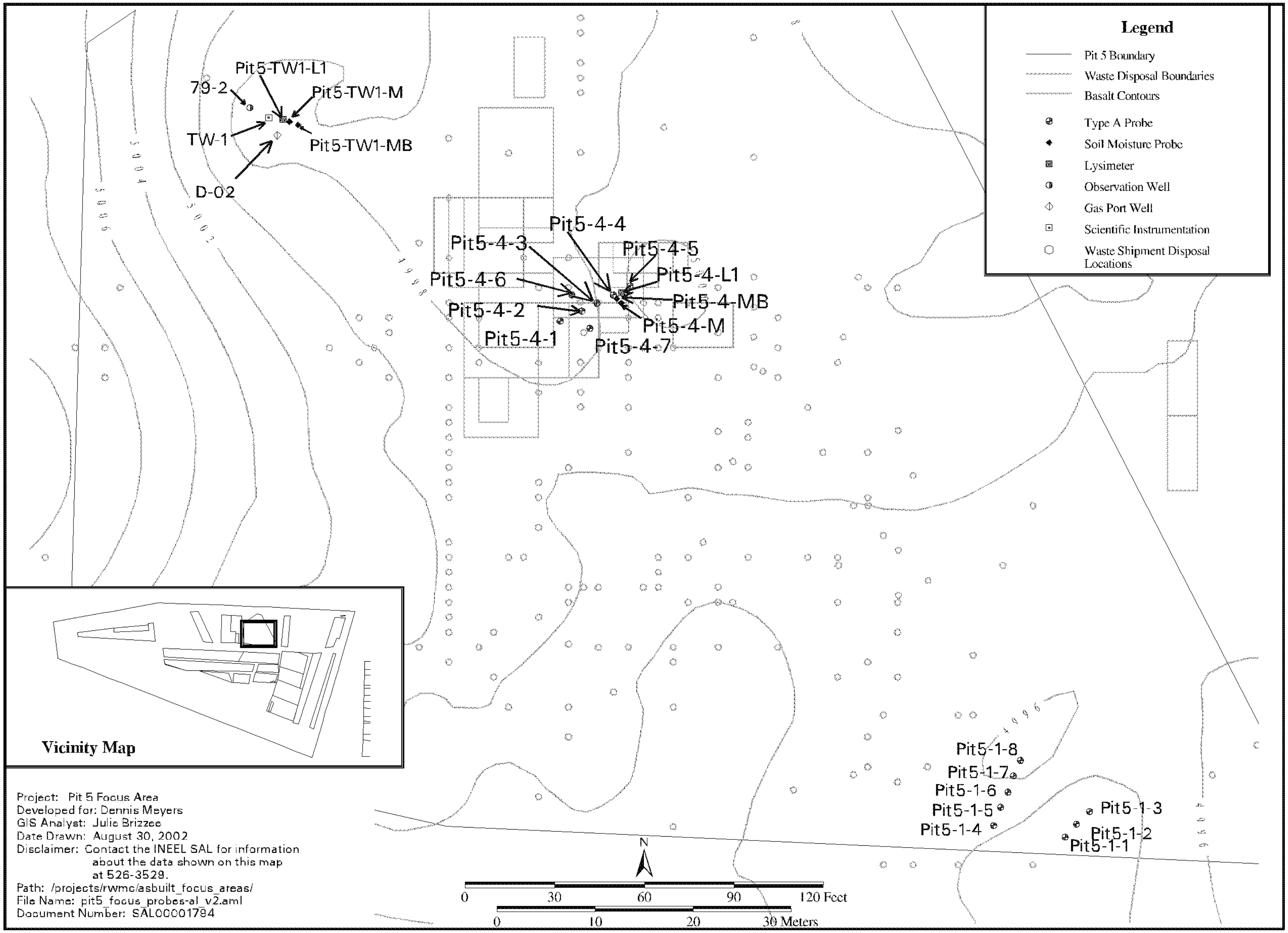

Figure 3-17. Probes installed in the uranium and enriched uranium focus area in Pit 5.

in the area contained U-233 waste from Building 881. Another three drums from these two disposals were reported in WasteOScope (INEEL 2001d) to contain U-233 from Building 771. Another important consideration in selecting this site for investigation is its disposal location along the southern perimeter of Pit 5. Confidence is higher for disposal location information near the pit boundary compared to information for disposals near the center of a large pit like Pit 5. Eight Type A probes were installed along two transects in Pit 5.

Pit 5-4. Type A probes were placed in an area shown by the WasteOScope to contain 14 of 147 drums that originated from RFP Building 886, a building established to perform criticality testing on highly enriched uranyl nitrate. In addition, all but 16 of the drums in this disposal originated from RFP uranium processing facilities (i.e., Building 881, 883, or 886), thus increasing the likelihood of detecting the targeted uranium. Rocky Flats personnel[h] indicated that two enriched uranium-contaminated gloveboxes and associated piping were disposed of from Building 886, but the time of disposal could only be described as many years ago. WasteOScope (INEEL 2001d) was queried and a Rocky Flats disposal was found that described glovebox deactivation, decontamination, and decommissioning-type waste and selected combustibles originating from Building 886. This waste likely would contain significant concentrations of enriched uranium. Rocky Flats personnel (see footnote h) also noted that numerous spills containing highly enriched uranyl nitrate occurred in Building 886, and often were mopped up. If these mops, classified as combustible waste, were disposed of, they would contain significant U-235 activity, as well. Seven Type A probes, two soil moisture probes, and one lysimeter were installed in this area.

3.7.9 Activated Metal Investigations

This investigation primarily was focused on evaluation of C-14. Carbon-14, as an activation product, is a byproduct of reactor operations. The amount of C-14 disposed of and its release rate are uncertain. An effort is ongoing to refine the inventory of C-14 in the SDA. Using the current assumptions on the release rate, preliminary evaluations of potential risks from the IRA (Becker et al. 1998) indicate that C-14 amounts still could be above acceptable risk levels.

Most C-14 inventory in the SDA is from disposal of activated metal. Some of this disposal inventory is in the form of reactor core components, including beryllium reflector blocks and end pieces from reactor cores. The remaining activity is mostly in ion exchange resins. Typical C-14-bearing waste was disposed of in the SVRs (or possibly in the trenches) in the earlier years of operation (see Sections 3.1.2.4.2 and 3.2.1).

Type B probes were installed near soil vaults indicated by WasteOScope to contain C-14-bearing waste. These probes were placed to yield information about release and potential transport of C-14 in the subsurface. Carbon-14 can be transported in both vapor and dissolved phases. Moisture monitoring also was conducted near the vaults to assess the moisture state of surrounding soil. Two activated metal disposal sites were evaluated during the probing project investigation. One site, SVR-12, contained activated stainless steel and the other site, SVR-20, contained activated beryllium. Detailed criteria used to select each site for investigation are given in the Type B Probe FSP (Salomon 2001).

3.7.9.1 **Activated Metal (Stainless Steel) Investigation at Soil Vault Row 12.** Soil vault Row 12 was selected to monitor activated stainless steel because disposal information indicated that the SVR had the target material and did not contain other interfering materials (e.g., beryllium) that could

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h. J. Anderson, radiological engineer and current Building 886 facility manager, Rocky Flats Plant, telecommunication with Hopi Salomon, Washington Group International, Idaho Falls, Idaho, November 2000.

greatly complicate subsequent analyses. WasteOScope data (INEEL 2001d) indicated the disposal of highly irradiated waste at this site. Further investigation indicated that the waste contained disposals of highly irradiated stainless steel end pieces from spent Experimental Breeder Reactor II fuel elements (Salomon 2001). This highly irradiated stainless steel probably was disposed of in scrap cask inserts that were open at the top and perforated on the bottom, allowing contact with surrounding soil (Salomon 2001). Because of shallow soil conditions at SVR-12, these disposals were made using an excavator in lieu of an auger rig to create the hole for burying the scrap cask inserts. The disposals of interest were handled remotely, using a free air transfer technique. As a result, exact positioning of the disposed waste was not possible.

Historical information identified in the Type B Probe FSP indicated that the SVR-12 disposal area was no deeper than 2 to 4 m (8 to 12 ft) belowground surface at time of disposal (Salomon 2001). However, because of subsequent flooding, RWMC operations personnel placed approximately 3 m (10 ft) of fill in an area close to where these shipments were buried. Results of the probing did not support this because the greatest depth at which a probe could be installed at SVR-12 was only 3.81 m (12.5 ft) belowground surface (Probe SVR12-2-VP 1). Specifics about waste disposal at SVR-12 and the rationale used for selecting probe placement are given in the FSP (Salomon 2001). Probe type and completion intervals for probes placed at SVR-12 are represented in Table 3-17. Physical placement of the probes at SVR-12 is represented in Figure 3-18. Samples collected from vapor ports at SVR-12 are being analyzed for the radioactive gas C-14, while samples collected from lysimeters are being analyzed for gamma spectroscopy and a suite of radionuclides (i.e., C-14, H-3, Nb-94, Ni-59, Ni-63, and Tc-99) to support modeling activated metal release characterization. These results will be used to evaluate the validity of the assumptions used in the IRA.

Table 3-17. Probe completions supporting activated metal assessment.

	Probe Type							
	Tensiometer		Soil Moisture Probe		Lysimeter		Vapor Port	
Cluster Name	Probe Name	Instrument Depth (ft)	Probe Name	Instrument Depth (ft)	Probe Name	Port Depth (ft)	Probe Name	Port Depth (ft)
SVR-12			SVR-12-M	11.4				
			SVR-12-MI3	8.4				
			SVR-12-MI3	4.3				
SVR12-1	SVR12-1-T3	10.8			SVR12-1-L1	11.1	SVR12-1-VP1	11.7
	SVR12-1-T2	8.4			SVR12-1-L2	5.8	SVR12-1-VP2	7.6
	SVR12-1-T1	3.6					SVR12-1-VP3	2.7
SVRI2-2							SVR12-2-VP1	11.9
							SVR12-2-VP2	7.7
							SVR12-2-VP3	2.6
SVRI2-3							SVR12-3-VP1	11.8
							SVR12-3-VP2	7.6
							SVR12-3-VP3	2.5
SVR-20			SVR-20-M	17.4				
			SVR-20-MI3	13.8				
			SVR-20-MI3	4.4				
SVR20-1	SVR20-1-T3	16.4						
	SVR20-1-T2	12.7						

Table 3-17. (continued).

Cluster Name	Tensiometer Probe Name	Tensiometer Instrument Depth (ft)	Soil Moisture Probe Probe Name	Soil Moisture Probe Instrument Depth (ft)	Lysimeter Probe Name	Lysimeter Port Depth (ft)	Vapor Port Probe Name	Vapor Port Port Depth (ft)
	SVR20-1-T1	8.3						
SVR20-3							SVR20-3-VP1	6.3
							SWO-3-VP2	12.9
							SWO-3-VP3	15.0
SVR20-5							SWO-5-VP3	17.2

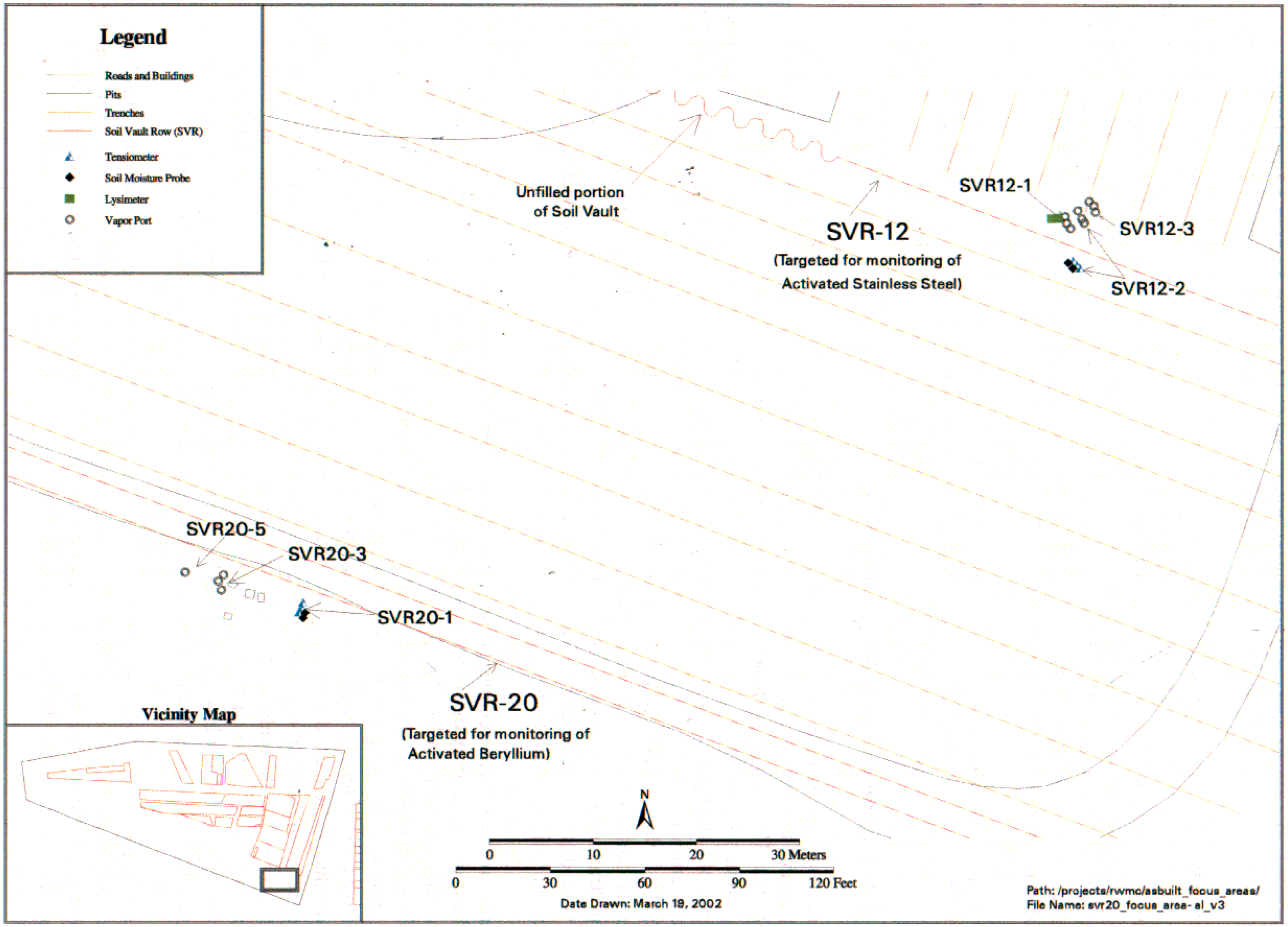

Figure 3-18. Probes installed in the activated metal focus area.

3.7.9.2 **Activated Metal (Beryllium) Investigation at Soil Vault Row 20.** Six neutron-activated beryllium reflector blocks from the INEEL Advanced Test Reactor were buried in SVR-20 in 1993. The blocks contained significant tritium and C-14 activity. Section 3.8 contains a summary of beryllium disposals at SVR-20, as well as previous monitoring activities conducted nearby.

Before the SDA probing project, a monitoring array was established to characterize the migration of tritium and C-14 at SVR-20. The monitoring array installed as part of the probing project augments the monitoring that began in 1994. Vapor ports have been installed to enhance lateral monitoring for tritium and C-14 at a greater distance from the source than previously installed vapor ports. Moisture monitoring also is being conducted near the vault because the moisture state of the surrounding soil affects sampling and evaluation of soil gas data. Probes installed for the probing project investigation at or adjacent to SVR-20 are included in Table 3-18 and Figure 3-18.

Vapor ports installed around SVR-20 are being sampled with a dedicated system for tritium sample collection. The system consists of a vacuum pump, control unit, and desiccant-filled moisture traps to monitor tritium in the vapor phase, which was not an objective of sampling at any other site.

3.7.10 Waste Zone Moisture Monitoring Array

Three moisture monitoring transects and an additional array were established by pairing tensiometers and soil moisture probes at various locations and depths in and immediately adjacent to some SDA pits. The primary purposes for these transects were to identify the amount of water that infiltrates through the waste, to investigate the effects of cover material on reducing infiltration, evaluate the influence of existing ditches on moisture movement, and to determine whether local conditions could enhance contaminant release. Results of modeling are extremely sensitive to the infiltration rates used in the simulations. Not only does infiltration provide the mechanism for contaminant migration, it also influences the corrosion rate of metal containers and eventual release from the waste form. Though Site-specific infiltration rates are implemented in this ABRA (see Section 5), the moisture monitoring transects were deployed to hrther validate the OU 7-13/14 comprehensive RI/FS model parameters and to enhance the infiltration data set for any hture analysis of the SDA.

Three north-to-south trending probe transects were installed in and adjacent to the north side of Pit 4, and an additional array of probes was placed in the west end of Pit 10. In each Pit 4 transect, three clusters of probes were installed. The first cluster in each transect was installed near the drainage ditch north of Pit 4, the middle clusters were established near the north boundary of the pit, and the third, (southernmost) clusters were installed well into the waste in Pit 4 (see Figure 3-19). In most probe clusters, three pairs of tensiometers and soil moisture probe instruments were installed to monitor three different depths. As field conditions allowed, a tensiometer and soil moisture detector were paired near the contact between the overburden and waste, near the middle of the waste zone, and near the contact between the waste and the underburden or near the basalt contact. The instruments in the middle of the waste were installed with the tensiometer completed in the upper third of the waste zone and the soil moisture detector completed lower in the middle of the waste zone to increase coverage in the waste. Final instrument completions in the moisture monitoring transects are given in Table 3-18.

The location of the transect known as MM1 was selected to monitor the effect of water that flows through a culvert under the east-west road (see Figure 3-19). The MM2 transect is centrally located along the northern edge of Pit 4. The MM3 transect is located just east of the 1-3 monitoring well pair, which showed wet conditions above the B-C interbed at a depth of approximately 27.4 m (90 ft) during previous investigations.

Cluster MM- 1

Tensiometer Name	Instrument Depth (ft)	Soil Moisture Probe Name	Instrument Depth (ft)
MM1- 1- T3	17.7	MM1- 1	17.8
MM1- 1- T2	10.5	MM1- 1B	11.6
MM1- 1- T1	5.6	MM1- 1B	5.5
MM1- 2- T3	14.0	MM1- 2	13.9
MM1- 2- T2	9.3	MM1- 2B	10.7
MM1- 2- T1	5.6	MM1- 2B	6.0
MM1- 3- T3	11.7	MM1- 3	11.5
MM1- 3- T2	8.4	MM1- 3B	9.7
MM1- 3- T1	5.1	MM1- 3B	4.9

Cluster MM- 2

Tensiometer Name	Instrument Depth (ft)	Soil Moisture Probe Name	Instrument Depth (ft)
MM2- 1- T3	16.0	MM2- 1	16.0
MM2- 1- T2	11.9	MM2- 1B	12.5
MM2- 1- T1	6.7	MM2- 1B	7.3
MM2- 2- T3	9.2	MM2- 2	10.8
MM2- 2- T2	8.6	MM2- 2B	9.1
MM2- 2- T1	4.9	MM2- 2B	4.0
MM2- 3- T3	6.6	MM2- 3B	7.0
MM2- 3- T2	5.1	MM2- 3B	1.7
MM2- 3- T1	3.8	MM2- 3	3.0

Cluster MM- 3

Tensiometer Name	Instrument Depth (ft)	Soil Moisture Probe Name	Instrument Depth (ft)
MM3- 1- T3	9.7	MM3- 1	9.7
MM3- 1- T2	7.1	MM3- 1B	7.6
MM3- 1- T1	4.9	MM3- 1C	4.5
MM3- 2- T3	8.4	MM3- 2	8.5
MM3- 2- T2	6.6	MM3- 2B	7.0
MM3- 2- T1	5.0	MM3- 2C	4.0
MM3- 3- T3	17.0	MM3- 3	17.0
MM3- 3- T1	14.0	MM3- 3B	13.8
MM3- 3- T2	4.6	MM3- 3B	7.5

Cluster MM- 4

Tensiometer Name	Instrument Depth (ft)	Soil Moisture Probe Name	Instrument Depth (ft)
MM4- 1- T3	18.5	MM4- 1	19.4
MM4- 1- T2	14.9	MM4- 1B	14.7
MM4- 1- T1	5.7	MM4- 1B	14.7
		MM4- 1D	16.7
MM4- 2- T3	15.8	MM4- 2	17.4
MM4- 2- T2	11.4	MM4- 2B	12.1
MM4- 2- T1	4.9	MM4- 2B	4.7
		MM4- 3	9.1
		MM4- 3B	6.2
		MM4- 3C	4.8
MM4- 4- T3	9.5	MM4- 4	10.3
MM4- 4- T2	8.2	MM4- 4B	8.7
MM4- 4- T1	3.6	MM4- 4B	4.2
		MM4- 4D	10.9
MM4- 5- T3	13.5	MM4- 5	13.9
MM4- 5- T2	9.7	MM4- 5B	9.7
MM4- 5- T1	4.1	MM4- 5B	4.4

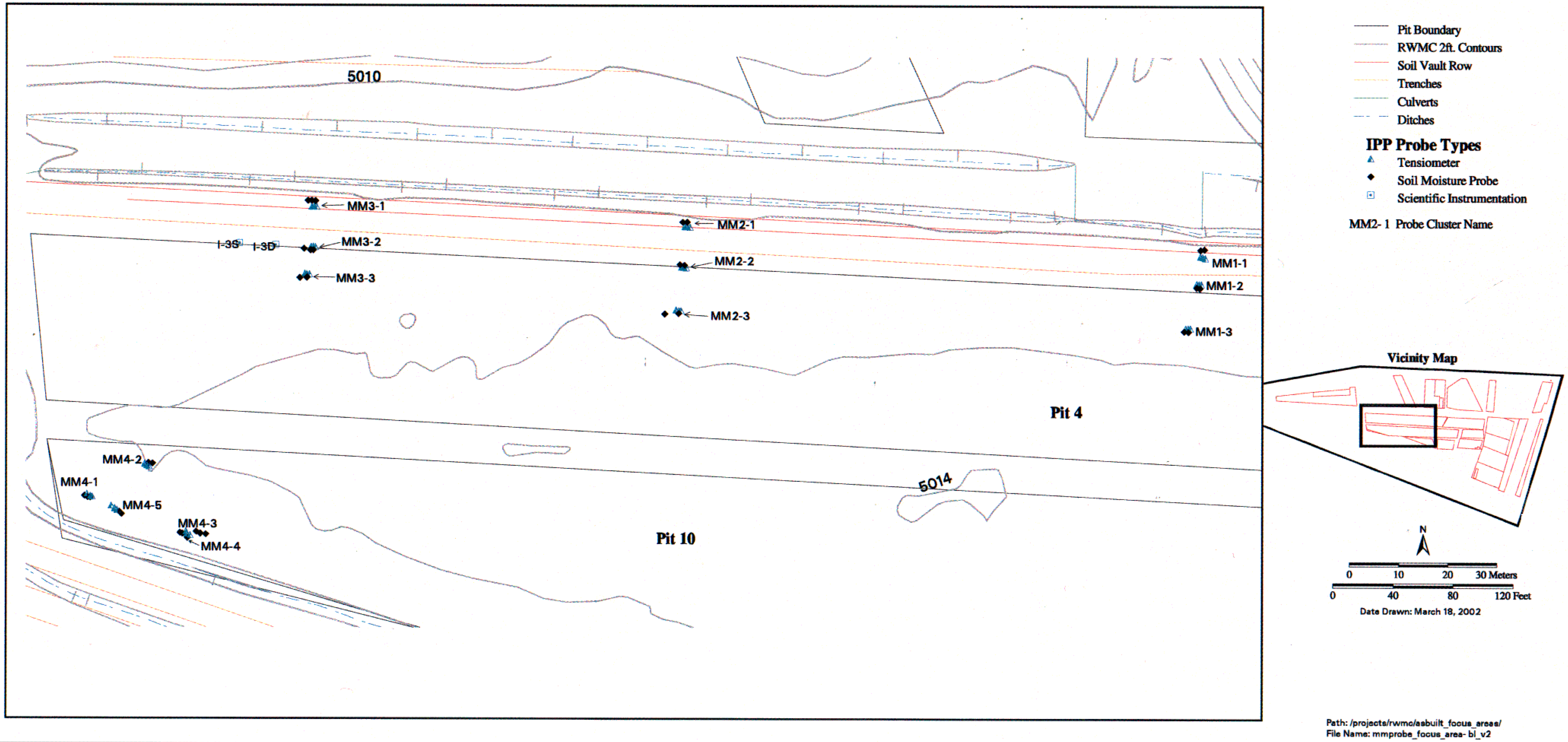

Figure 3-19. Probes installed to develop the waste zone moisture monitoring array.